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Wood-Based Panels Technology

L V L

Laminated Veneer Lumber

Overview of the Product, Manufacturing and Market Situation

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Fig. 1 Oekozentrum NRW, Hamm, Germany

1. Definition

Laminated Veneer Lumber (LVL) is a layered composite of wood veneers and adhesive. Hence it can be considered as a veneer based product.

2. Introduction

LVL is a versatile engineered product and combines the best of modern process technology with the aesthetic beauty of natural wood. It has been used structurally for several years in the Northern America and in many European countries.

LVL is made up of parallel laminations of veneer, glued and processed together to form material of thickness similar to sawn timber. The distinguishing difference between LVL and plywood is the orientation of the veneer layers as shown in Figure 2.

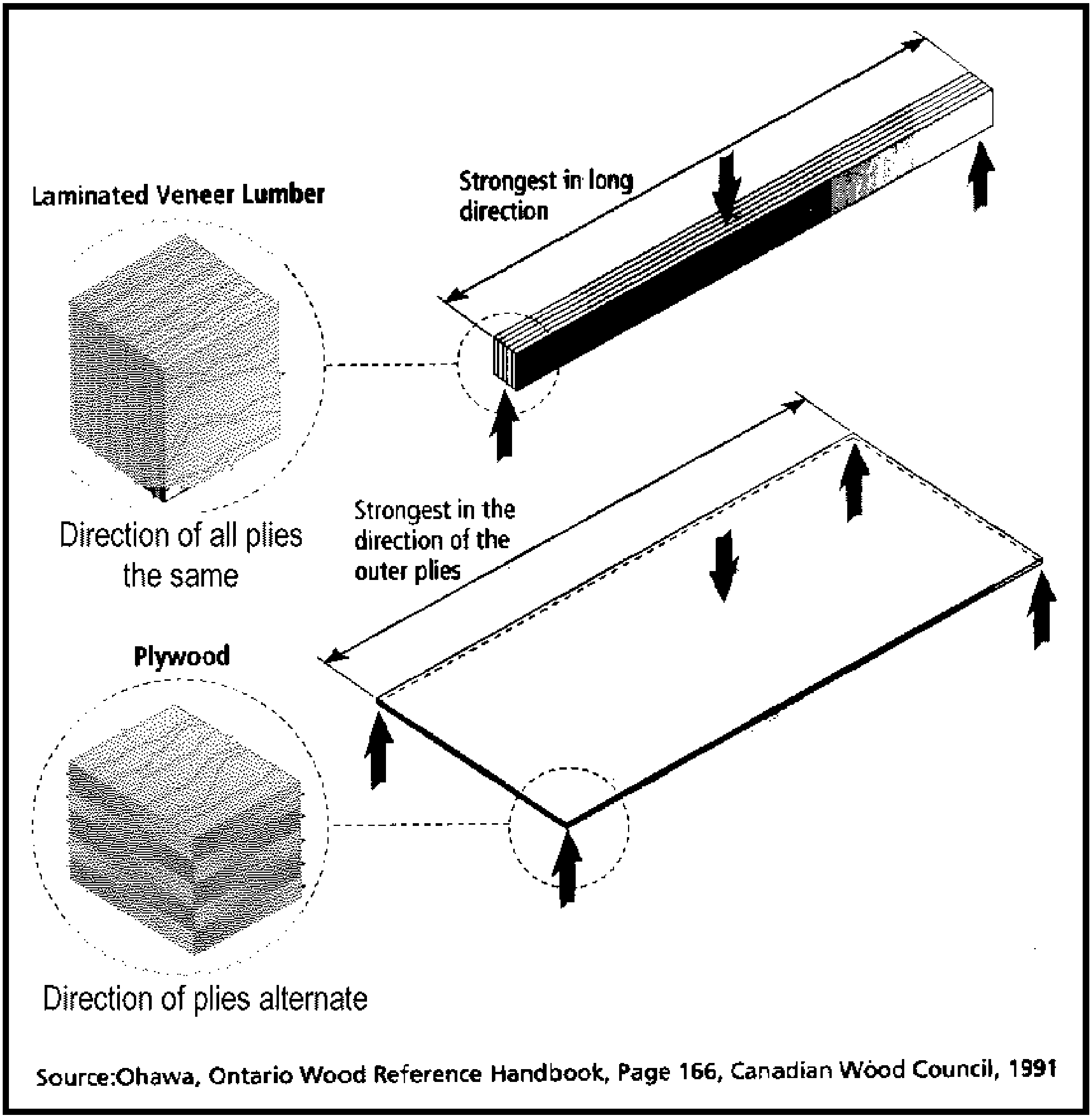

Fig. 2 Ply Orientation: LVL versus Plywood

LVL represents a new technology in wood utilisation and its production is steadily increasing and there is much development work under way in different locations in both the production methods and the applications of LVL. During the last twenty years LVL has become an important new product which has created considerable interests in the building field. LVL is a high-quality structural material with uniform engineering properties and dimensional flexibility which makes it superior to sawn timber and glued laminated timber, particularly for large-span structures.

Its applications range from public buildings, large prefabricated buildings, product components and industrial warehouses to customized wooden houses. New application are constantly being developed in close co-operation with customers and wood-construction professionals. In short, LVL provides an ideal solution, when features such as durability, light weight, and dimensional precision are essential. These attractive features lead an ever-increasing popularity both in Europe and the United States. The principal European market countries for LVL are the Scandinavian countries, Germany and France.

LVL's unique strength and versatility is also shared by another close relative, Parallel Strand Lumber (PSL). PSL is a structural wood product which is constructed from softwood veneer that has been further sized into long and narrow strips that are then glued into parallel laminations. In this report PSL is not further described.

Engineered lumber is enjoying increased market acceptance and is displacing solid-sawn structural timber. There are many reasons for the rising popularity of this engineered wood products.

Large diameter trees for sawn timber are less readily available in some markets creating an excellent opportunity for LVL. The veneering and gluing process of LVL enables large members to be made from relatively small trees thereby providing for efficient utilisation of wood fibre. In other words, LVL enables small trees to be converted into large size planks. And, LVL can be manufactured from raw materials which could not previously be utilised.

With minor modifications, plywood mills can be converted to produce LVL, extending their product lines and opening up new markets.

3. History of LVL

LVL was first used to make airplane propellers and other high-strength aircraft parts during World War II.

The term veneer was somewhat synonymous with plywood prior to the 1970s. But all that began to change during the 70s when Art Troutner and Herold Thomas (in the USA) used parallel laminated plies of veneer without crossbanding (cross-lamination) to form the top and bottom flanges of structural I-beam shaped trusses and joists. Troutner and Thomas officially established their company, presently known as TJ International (USA), in early 1960 to sell an unusual new product called "truss joists". This open-web truss used machine stress rated timber as top and bottom chords. These chords were connected by steel webbing. This remarkable new product carried more load per pound of its own weight than any other structural product then available.

Troutner continued to improve the open-web product and invent additional lumber-based products. A unique floor joist designed for the upper-end residential market was soon developed. A connecting web of plywood replaced the open-web steel tubing. The result was a structurally efficient I-shape that concentrated the wood at the top and bottom where it is most needed for strength and support.

The market was ready for this product and sales climbed. The product's light weight, strength, uniformity, and ability to span long distances made it an ideal substitute for solid sawn timber.

However the production of consistently high quality I-beams required a dependable supply of high-strength flange timber, and solid sawn timber of this quality was becoming increasingly difficult to secure.

Troutner's inventive mind then shifted to a new level of creativity. He subsequently developed a parallel laminated assembly of 1/10-inch (2.54mm) thick Douglas Fir veneers to create timber of sufficient strength and uniform properties to be used as flange material. The rough assembly, called a billet, was then ripped into desired widths.

TJ's MICRO-LAM, composed of plywood webbing and laminated veneer lumber (LVL) flanges, then emerged as the first commercially successfully engineered timber mass produced by any company in the world.

Demand, TJ's products and the manufacturing facilities for these products expanded during the 70s. The TJ product and the market it served were well prepared to take advantage of the scarcity of large-diameter old-growth timber which had been the traditional source of solid sawn trusses, headers, beams, and joists.

TJ International is nowadays the leading manufacturer and marketer of engineered lumber products in the world.

Fig. 3 An I-Joist and sawn timber

4. Manufacture of LVL

Debarked 4,9 m long spruce logs are soaked in +50 ° C water for 24 hours. Logs are conveyed to the cross cut saw and cut into 1,6 m peeler logs. Blocks are rotary cut to 3,2 mm thick veneer, which are cut to sheets and the length depends on wanted LVL-lumber length. Peeler core and rounding waste are chipped and used for manufacture of paper. Veneers are dried in a continuous roller drier so that moisture content is below 5%, what is adjusted with automatic moisture meter.

In lay-up line sheets are graded, too small and narrow sheets are removed and too wet sheets are separated to re-drying. Classifier chooses the best sheets as face veneers. Sorting is organised so that weight of each veneer is determined and veneers are stacked into different piles to mix the veneers. The leading manufacturer in the USA, TJ International, grades the veneers with advanced ultrasonic grading technology in addition to visual grading. Dependent on the end use of the LVL product the ultrasonically graded veneers are specifically located in the material to efficiently utilise the strength characteristics of the veneer grades. For example, if the end use of the LVL is a scaffold plank, the higher grade veneers will be placed at the outer faces of the plank.

The scarf saw makes 3 cm long chamfers in both ends of the veneers. Glue is added on the scarf of the face veneer. Feeding is organised so that face and core veneers are fed in a correct order. Glue is thermosetting phenolic resin. Using special type of curtain coater, glue is spread on upper side of each sheet, except on the upper faces. The sheets are laid up to a continuous mat, so that veneer scarf-joints are more than 10 cm apart from each other.

In manufacture of Kerto-S veneers are laid up so the grain direction is the same in all veneers. In Kerto-Q and Kerto-T some veneers are laid so that their grain is contrary to the grain direction most of the veneers. This construction gives rigidity for the LVL it does not warp and twist.

Samples for different Kerto-Q lay-ups:

thickness	m	n	Symbol
27	9	2	II-III-II
33	11	2	II-IIIII-II
39	13	3	II-III-III-II
45	15	3	II-IIII-IIII-II
51	17	3	II-IIIII-IIIII-II
57	19	4	II-III-IIII-III-II
63	21	5	II-III-III-III-III-II
69	23	5	II-IIII-III-III-IIII-II
thickness in mm m = total no. of veneers n = no. of rectangular veneers			

When the wanted thickness is reached, the mat is pre-pressed to spread the glue evenly on the downside of the veneers. Billets, width 1,6 m and thickness 27-75 mm, are cut to desired length (max. 26 m), than they are fed into the hot-press. This hot-press is a two-daylight press, the pressing temperature is about +145 ° C . The pressing time depends on the thickness of the billet.

LVL-billets are cut accurate to the customers requirements. In rip saw billets are cut to either longitudinal direction to beams (Kerto-S and Kerto-T) or to boards (Kerto-Q). In Finnforest factory there is a special saw for oblique sawing, so billets can be sawed straight or oblique by customers request.

5. Structural Properties of LVL

1. Introduction

The most important reason for LVL's success are the qualities of the product itself and its properties. The manufacturing process provides LVL with a homogenous structure.

In LVL, usually the grain of each layer runs in the same (long) direction with the result that it is strong when edge loaded as a beam or face loaded as a plank.

This kind of lamination is called parallel-lamination, and it produces a material with greater uniformity and predictability than the same dimension material made by cross-lamination.

Cross-laminated LVL offers superior shrinkage properties perpendicular to the long direction of the board and increased strength properties if faced loaded as a plank.

2. Strength properties

One of the main ideas of LVL is to disperse or remove strength-reducing characteristics. LVL is an engineered, highly predictable, uniform lumber product, because natural defects such as knots, slope of grain and splits have been dispersed throughout the material or have been removed altogether within the veneer assembly. In addition to this, the veneer sheets are placed in specific sequence and location within the product to maximize the stronger veneer grades. This can be considered as an engineered configuration of the veneers.

Hence LVL's strength properties are consequently superior to those of glued laminated timber (glulam) or stress graded timber. The average of most strength properties is higher and the variation is significantly lower when compared to solid wood. LVL is a high-quality product that is more uniform and exhibit improved structural properties over sawn timber.

Product	**Bending Stress**	**Modules of Elasticity**	**Compression (perpendicular)**	**Horizontal Shear**
Laminated Veneer Lumber[b]	2,800	2,000,000	500	285
Parallel Strand Lumber	2,900	2,000,000	600/400[c]	290/210 [c]
Select Structural Douglas Fir	1,800	1,800,000	625	95

[a] For converting English to International System units, 1 psi = 6.89 x 103 Pa

[b] Bending Stress of LVL made entirely from high-grade veneers can be as high as 4,250 psi (29.3 Mpa)

[c] Parallel/perpendicular to wide face of strands

Source: Progressive Architecture, p.35 (R. McNatt and R.C. Moody)

Table 1: Comparison of Structural Properties Design Value (psi)[a]

The illustrated design values clearly compare favourably with high-quality sawn timber. While the modules of elasticity (also responsible for the stiffness) of LVL and PSL lumber are 10 percent higher than that of Douglas fir, the design strength in bending and tension is more than fifty percent higher.

In general it can be roughly said that the strength of LVL is 1,3 times the strength of glulam and 2 times the strength of sawn timber.

Like other products made by laminating pieces of wood together to create a structural element such as plywood, glulam, parallel strand lumber (PSL), or OSB/Waferboard, LVL offers the advantages of higher reliability and lower variability through defect removal and dispersal.

Yet, the strenght figures only tell half the story. According to a Smith Barney report:: Management (of TJM Trus Joist MacMillan, USA) speaks about the fact that if one were to support a 1000 square-foot floor with traditional 2" x 10" floor joists, it would require the cutting down of three trees. … (Trus Joist) wooden I-joists could do the same job and require the cutting down of only one tree. (…) This could result in a more efficient use of wood fibre. … (Dobi, 1993; From Plywood and Veneer-Based Products, Richard F. Baldwin,1995)

Whether the usage ratio is actually 3:1 or something less, recent design information and on-site experience indicates that an engineered structural system will require significantly less wood fibre when compared to solid wood.

3. Dimension stability

LVL is dimensionally precise, straight, it does not warp but can cup, and has minor changes due to humidity.

Every other veneer sheet in the veneer lay up is placed tight side up or down to ensure that the final product will not warp or twist.

4. Available Length

LVL is available in any length only limited by the press size or transportation restrictions. This fact makes is superior to sawn timber which is available from 1.8m up to 6.6 m in Finland. The maximun length of LVL is only exceed by glued laminated timber or finger-jointed structural sawn timber.

5. Available Width

The maximun width of LVL is restricted up to 80 mm depending on the manufacturing process. Compared with sawn timber or glulam, LVL is offered in much smaller widths, but because of its superior strength properties a smaller cross-section of wood material is allowed in load bearing structures. In addition to this the cross-section of LVL can be optimized by enlarging the hight of the cross-section as a major factor of the stiffness, and by accordingly reducing the width as a minor factor of the stiffness. Consequently the maximum available width of LVL is mostly sufficient enough for load bearing structures.

6. Uniformity

LVL is a uniform product.

7. Splitting, Fissures in the final product

Hence the veneers of LVL are dried to the desired moisture content, LVL does not shrink any further after hot pressing. As a result of this splits or fissures do not occur, whereas sawn timber and glued laminated timber are still subject to shrinkage due to non efficient drying.

8. Waste of Material

The waste of material while manufacture is minimal for LVL because nearly the whole log is used to manufacture veneer, and just a small amount of veneer is rejected due to defect removal.

In contrast the waste of material of sawn timber is considerable due to the sawing process itself and defects in timber, which have to be reduced or removed by cross cutting or edging.

9. Appearance

The natural aesthetic beauty of sawn timber includes the appearance of knots, wane, resin pockets, splits, slope of grain, and a few other less significant defects. Some of these defects have a great influence in the optical quality of the sawn timber and can diminish the value of the sawn timber in large extend.

LVL offers a more uniform surface with nearly the same beauty of natural wood. Scarf-joints visible on the surface might be a problem that reduces the quality of the optical appearance if dark coloured resins such as PF-resins are used.

10. Quality of the final product

LVL offers the more consistent quality compared to sawn timber. The variation in the properties is less significant.

11. Fire Resistance

LVL is a wood-based product and will react to fire much the same as a comparable size of solid sawn timber or glued laminated timber.

The Phenol-Formaldehyde resin adhesive used in manufacture are inert once cured. Therefore they do not contribute to the fire load and the strength of the bond is not adversely affected by heat. When used in fire-rated floor or roof assemblies, the performance of LVL is similar to solid sawn timber or glued laminated timber.

6. Fields of application

LVL is now used in applications where strength and dimensional stability are required.

Being a homogenous and dimensionally stable building material, LVL can be used in both bearing and non-bearing walls, as planks, as beams, as headers, in door and window frames, sliding door rails, steps, as well as in the roof trusses of single-family houses and engineered building constructions such as swimming halls, sport halls, etc.

Fig. 4 Exterior use of LVL boards, Seefeld, Germany

Fig. 5 Sports hall in Oulu, Finland

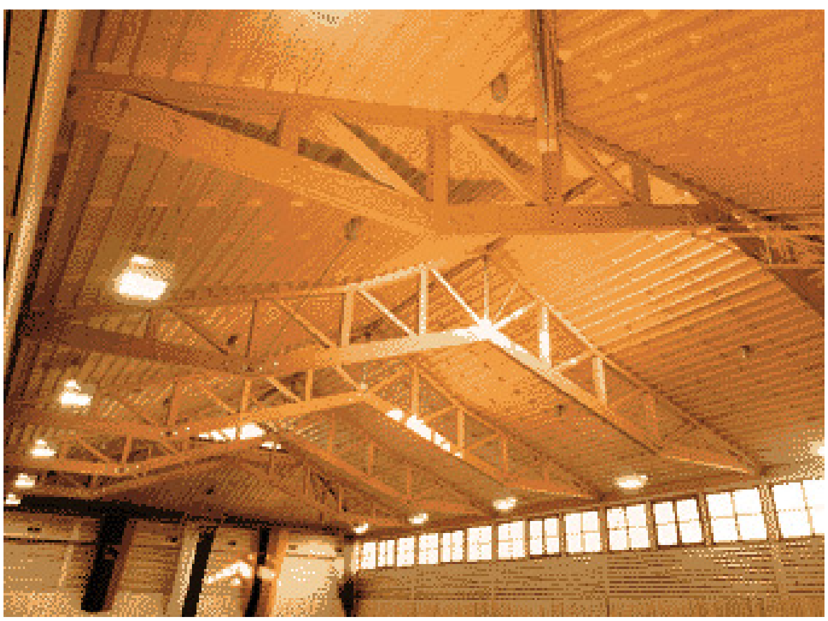

Fig. 6 Roof construction out of LVL-beams, Parkstein, Germany

7. Quality Control

The manufacture of LVL requires an in-house quality assurance organisation. Regular independent third party quality audits by a certification organisation are a required part of the manufacturers' quality assurance program.

LVL products are tested and approved for use by the major code and product evaluation agencies in the United States and Canada. All manufactured LVL products which have been tested and approved in this way should bear the seal of the certification agency, the manufacturer, date of manufacture, grade of LVL and reference to any applicable code or evaluation agency approval numbers.

LVL is a proprietary product having engineering properties that are dependent on the materials used in the manufacture and on the product assembly and manufacturing processes. As such, it does not meet a common standard of production. Therefore, designers and installers should follow the design, use and installation guidelines of the individual manufacturers.

The Canadian Construction Materials Centre (CCMC) has issued product evaluations for many of the LVL products marketed in Canada. In the United States, most manufacturers have obtained product evaluation reports from the Council of American Building Officials (CABO).

Currently, a standard for the specification for evaluation of structural composite lumber products (such as LVL and PSL) is under development by ASTM. This standard will outline procedures for establishing, monitoring and re-evaluating structural capacities of structural composite lumber and will also detail minimum requirements for establishment of quality control, assurance and audit.

8.1 Development of the LVL production lines worldwide

The machinery to produce LVL is now available from several machinery manufacturer and is utilized by an increasing number of forest products manufacturer.

The latest information given from Raute Wood Processing Machinery, Finland is:

LVL is manufactured in the United States, Canada, Finland, Japan, Australia and New Zealand. LVL's growing popularity is also evidenced by the fact that Raute Wood Processing Machinery current order book includes five new LVL production lines. Two are being installed in Indonesia for Surya Dumai Group, while Keytec is erecting a line in Japan. This is already the second LVL line this Japanese company has ordered from Raute Wood. These lines will initially produce non-structural LVL, with the intention being to produce structural product in the future.

Finnforest is also expanding its production in Finland and Evans Products in B.C., Canada has also purchased a Raute Wood LVL line.

8.2 LVL Manufacturer in Europe

KERTO business unit is a significant part of Finnforest's operations.

KERTO is a registered trademark. The Figure below shows the typical KERTO-Trademark.

KERTO®

KERTO manufactures and markets Kerto-LVL (laminated veneer lumber), developed as a result of the company's own research and development activity. KERTO's mill is located at Lohja in Southern Finland.

Kerto-LVL is an exceptionally strong wood panel product made by gluing together veneers rotary-peeled from Finnish softwood.

Finnforest has been the only company in Europe that manufactured this product until 1998. The annual production capacity of the Kerto-LVL mill is approximately 60,000 m3. Exports account for almost 90% of total output. The most important market areas are Germany, France, Sweden and the United States.

The manufacturing line of Kerto is certificated for ISO 9001, which means steady quality processes and remaining quality for the customers.

The swedish company Vänerply, one of the biggest plywood manufacturer in Europe, started their LVL production in the beginning of 1998 an is going to become the only competitor for KERTO in Europe.

Fig. 7 Manufacturing plant in Lohja, Finland

Finnforest's and the KERTO business unit's KERTO-LVL experts world-wide work in close collaboration with the products end users. A high-quality customer-oriented product coupled with technical expertise in marketing is a powerful combination highly respected by professionals in the construction industry. KERTO continuously enhances its customer service and its products. Kerto-LVL products are further processed at the mill to fit the customer's application needs.

8.2.1 More about Kerto-LVL

Kerto-LVL is a nature-friendly wood product made from Finnish spruce trees utilizing the latest technology. It is a stress-resistant structural material, used in securing both beams and plates. Due to its homogeneous and weather resistant glue structure, Kerto-LVL is very strong, dimensionally precise and straight. It does not warp and has only minor changes due to humidity. Kerto-LVL maintains these properties and is very fire resistant.

As a loadbearing material, Kerto is suitable for floor joist, lintels, purlins and for all roof shapes as joist and apperture beams. The range of use varies from industrial and public buildings to industrial houses and demanding renovations. Kerto-LVL is also being used in other areas of application: in building bridges and water towers, mobile homes, railway sleepers, in noise barriers on motorways, in ladders and scaffolding structures and also as posts for both load-bearing and non-load-bearing walls.

Multifunctional use of raw material gives designers great freedom to create a varied environment. Naturally.

Fig. 8 Solar tower "Heliotrop", Freiburg, Germany

8.2.2 Finnforest - Building Products Division

Demand for the Division´s products showed a marked increase over the year. A notable increase in private consumer demand in Finland made a marked difference, as in this division the domestic market accounts for a much larger share of the total sales than in other business divisions. Sales volumes and prices were good for windows, doors, particle-board and melamine-coated board.

The majority of laminated veneer lumber (LVL) produced by the Kerto Business Unit was exported to the European market. Favourable economic development boosted the demand for LVL products to the extent that a need for additional production capacity became evident.

Net sales of the Kerto Business Unit totalled FIM 190.6 million in 1997 (FIM 178.5 million), with exports representing a 64% share. The focus for exports shifted from USA to central Europe, where markets are good for highly-processed products with higher prices. Sales were hindered by the insufficient capacity of the Kerto Business Unit, and as demand on the European market grew significantly, an important decision - with far-reaching results - was made to raise the production capacity from the current 60,000 cubic metres to 100,000 cubic metres.

The unit´s financial performance in 1997 was good.

The Building Products Division's net sales in 1997 were FIM 542.7 million (FIM 566.9) and employed 657 people in the end of the year 1997.

Fig. 8 Bureau Building, Sortimo

9. Appendix

This report is mainly based on information found in the following sources:

- Annual report 1997, Finnforest Oy, Finland
- Raute Wood Processing Machinery Ltd, Finland
- Kerto, Kertopuu, different product information
- Plywood and Veneer-Based Products, Richard F. Baldwin, 1995
- handout: "Special types of Wood-based Panels", O. Liukkonen
- different Internet sites

Fig. 10 Frame truss in Espoo, Finland